Heavy flavor production in sqrt(s_{NN})=200 GeV *d*+Au Collisions at PHENIX

DNP 2013

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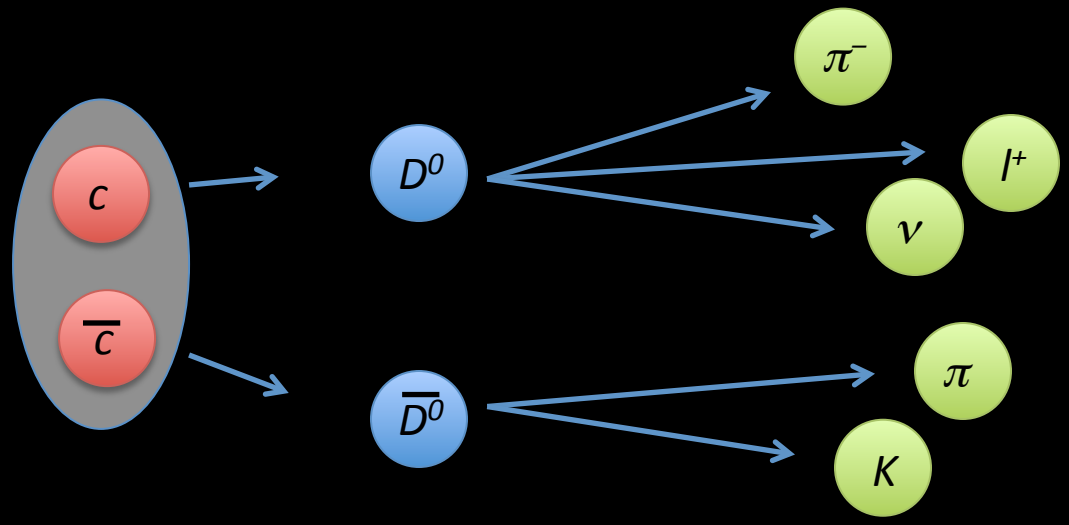
Heavy Flavor Production

Heavy flavor is an important probe of QGP in A+A collisions

- Produced early in the collision
- Open heavy flavor modification tests the medium coupling strength/ energy loss properties
- Heavy quarkonia melting probes the medium temperature

PHENIX is well-suited to measure open heavy flavor in the semi-leptonic decay channels.



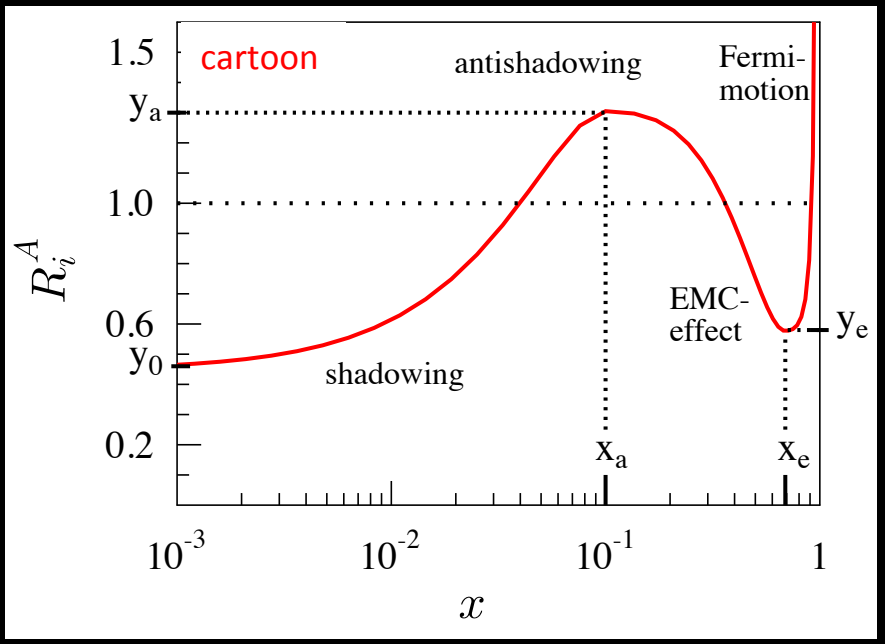
d+Au and "Cold" Nuclear Matter

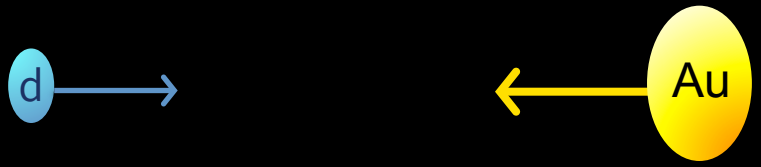
Need a control experiment to accompany *A+A* collision data.

p+A or *d+A* provide a test of our *A+A* probes without the presence of a hot medium.

CNM effects that are present regardless of hot medium:

1. Shadowing (modification of nuclear PDF)
2. Cronin enhancement
3. Initial-state energy loss
4. Nuclear break-up of heavy quarkonia states

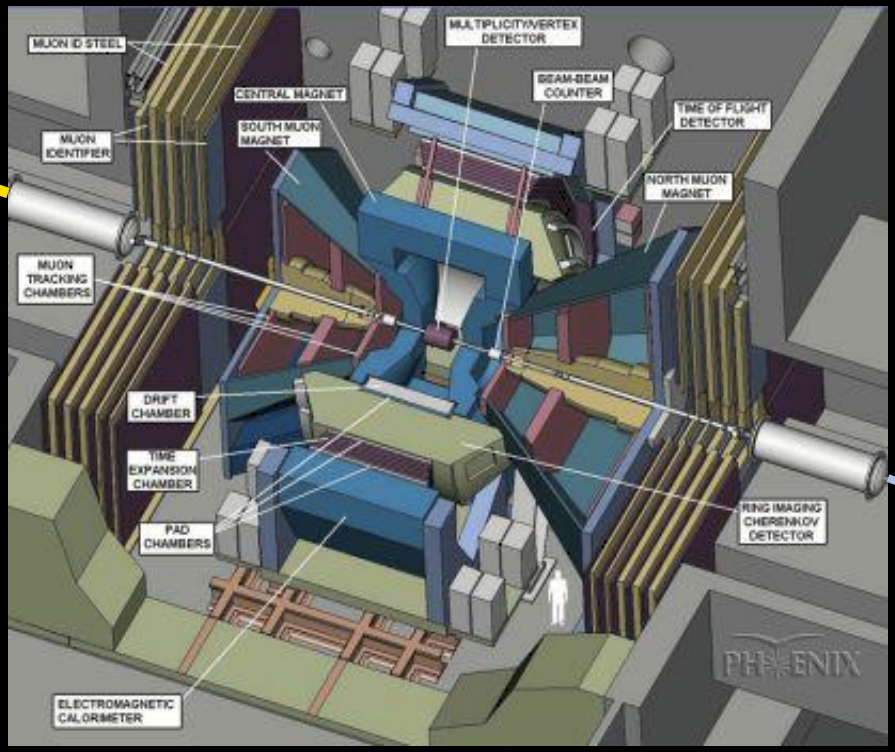




The PHENIX Experiment

Drift Chamber, Pad Chamber, EMCal & RICH detect electrons at mid-rapidity.

gold ion
y<0



Beam-Beam Counter used to measure centrality and collision *z*-position.

MuTr and MuID detect μ at forward & backward rapidities.

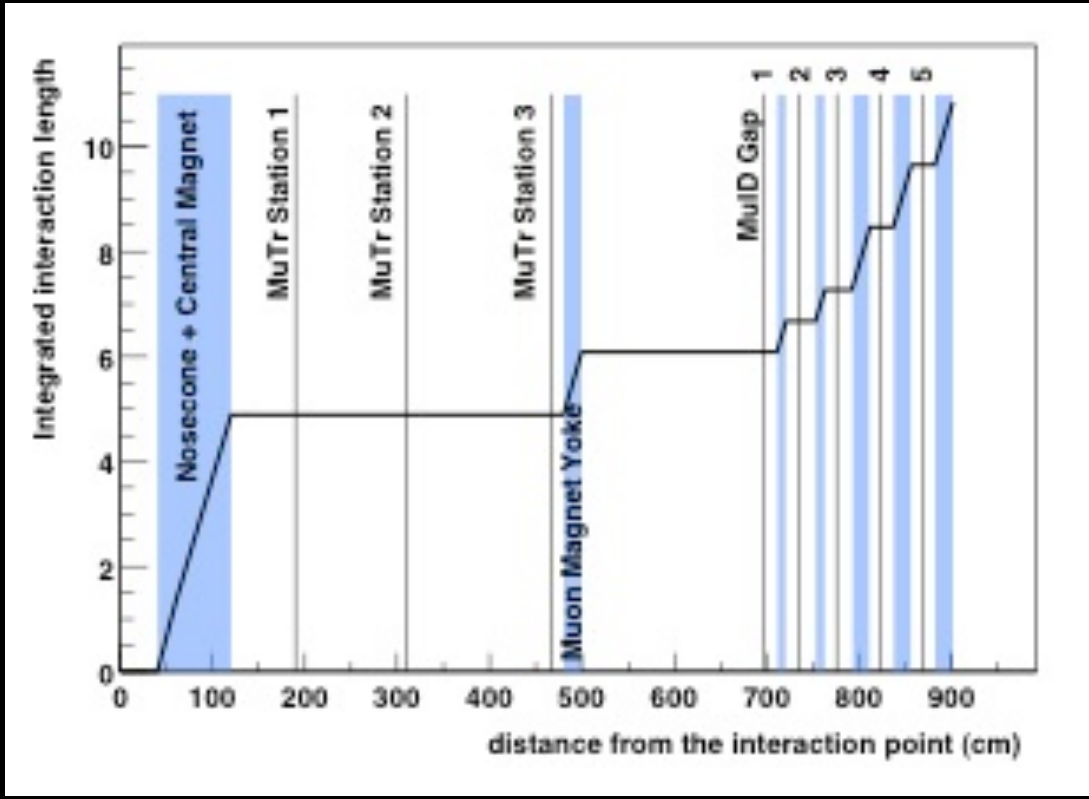
deuteron
y>0

PHENIX Muon Measurement

Muon Tracker gives momentum
Muon Identifier rejects hadrons

Muon arms have ~10λ of steel absorber between IP and the last MUID gap.

South (North) acceptance:
$1 < |\eta| < 2.2$ (2.4)



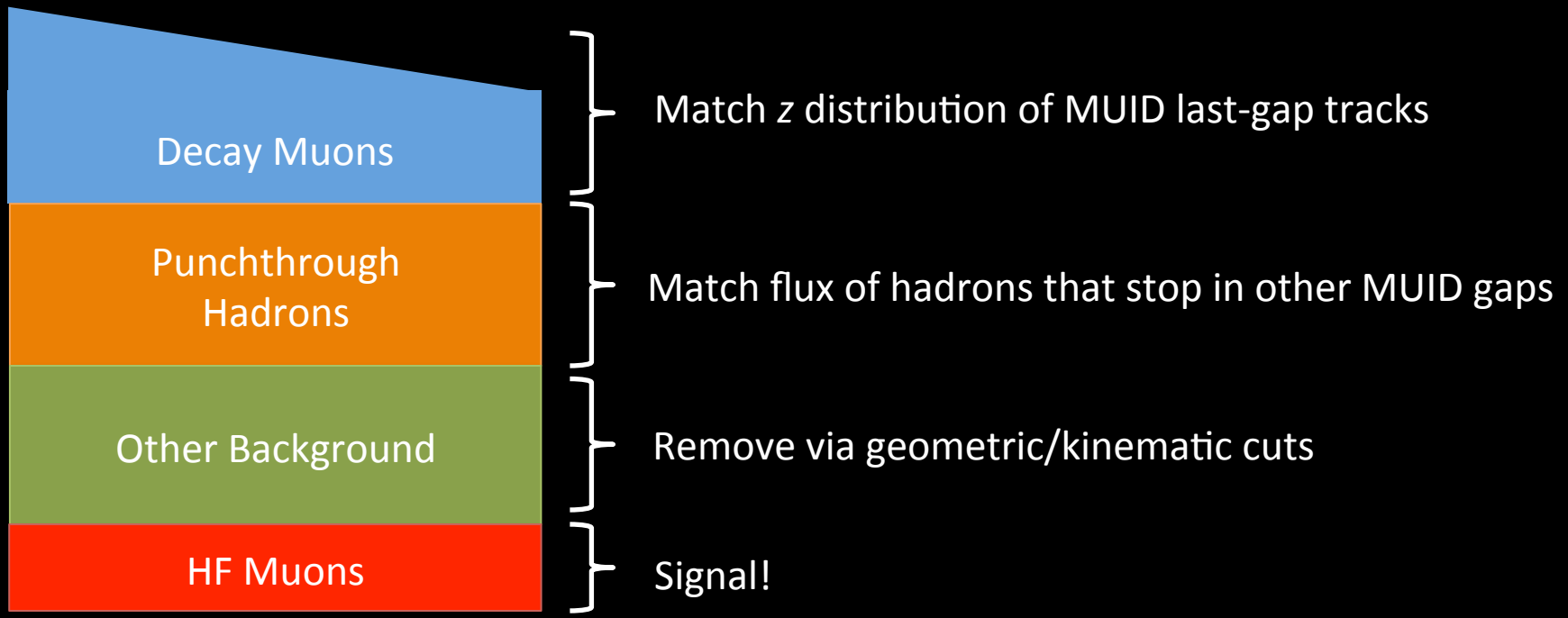
Main backgrounds for HF muons are:

1. Punchthrough hadrons – light hadrons that penetrate to back of MUID
2. Decay muons – muons from light hadron decays (mainly π,K)

Background Subtraction

Background is estimated via Monte Carlo simulation of a data-driven hadronic (π,K,p) cocktail

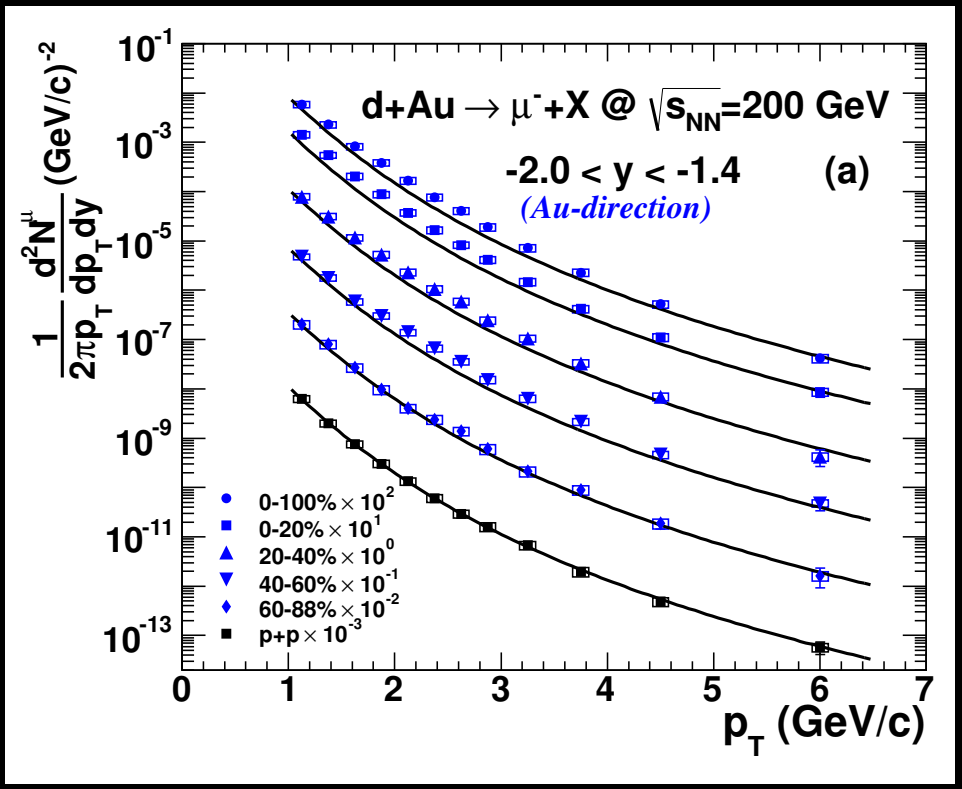
- Cocktail is tuned by matching multiple observables to data.
- Multiple GEANT3 hadronic interaction packages are compared to give systematic uncertainty.

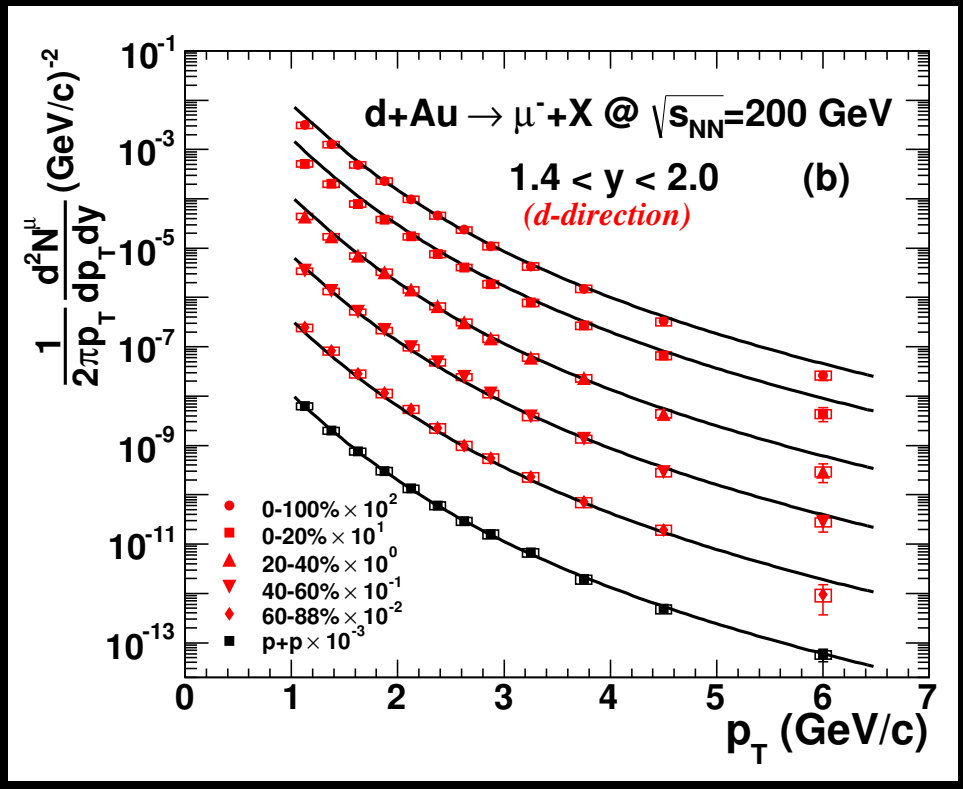


HF Muon Invariant Yields

PHENIX recorded new higher-statistics d+Au and p+p datasets in 2008 and 2009, respectively.

Submitted to PRL and available at arXiv:1310.1005





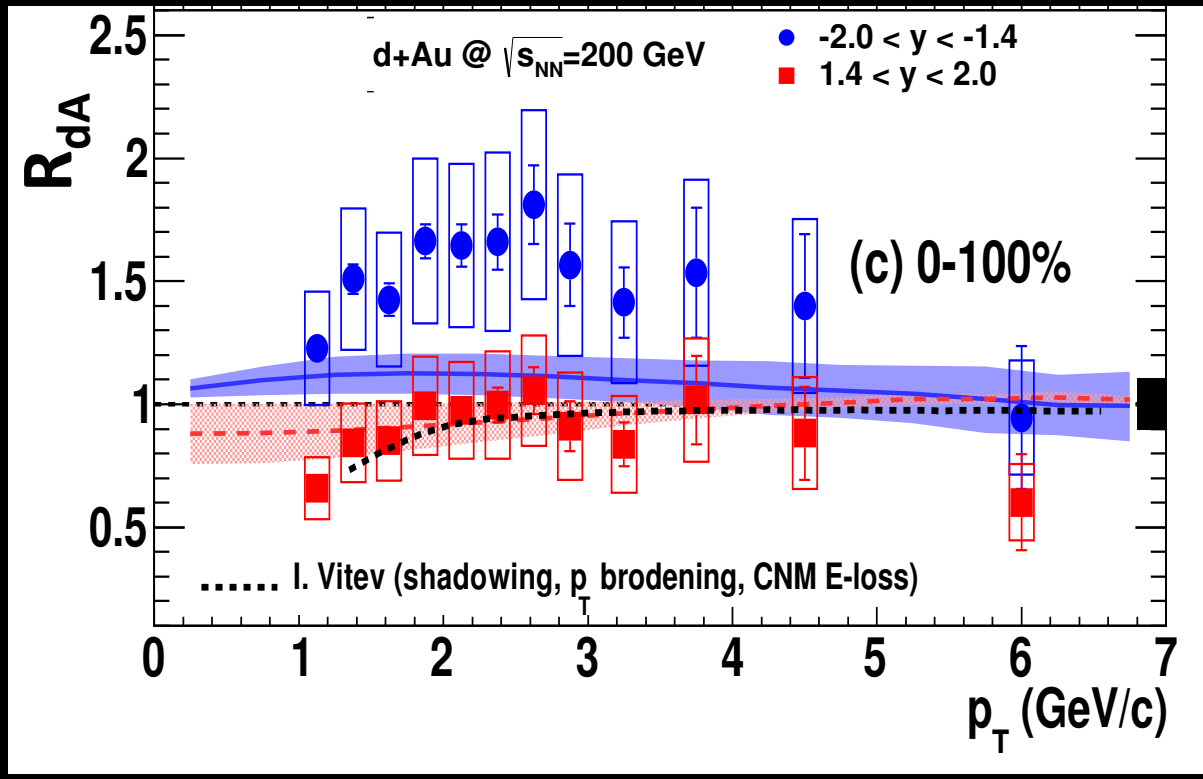
black lines – Kaplan fit to p+p, scaled by T_{AB}

Nuclear Modification Factor R_{dA}

$$R_{\mathrm{dAu}} = \frac{1}{N_{\mathrm{coll}}} \frac{dN_{d+Au}/dy}{dN_{p+p}/dy}$$

Little modification at forward rapidity

Strongly enhanced at backward rapidity



Agrees with EPS09s nuclear PDF calculation (blue, red curves) at forward, but not backward, rapidity.

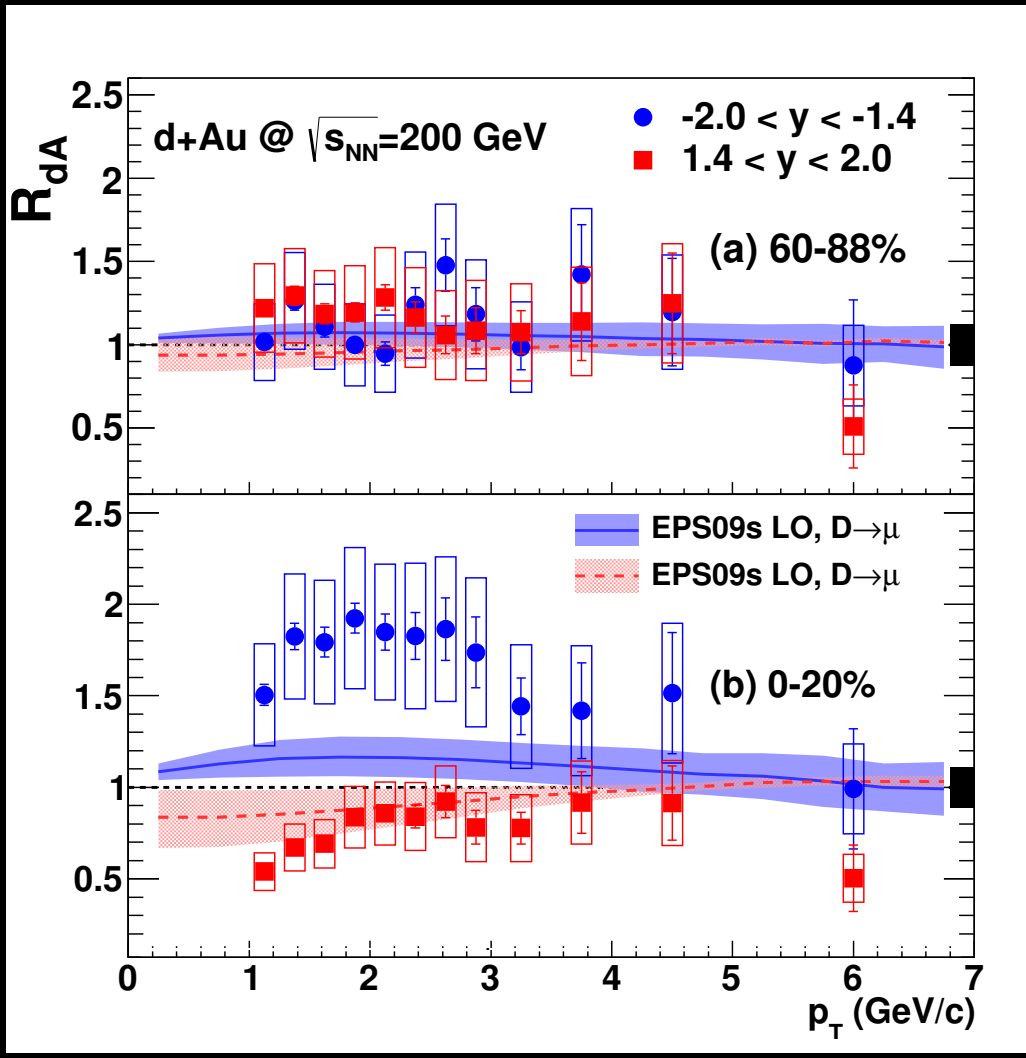
Calculation from I. Vitev also agrees with forward rapidity.

R_{dA} vs. p_T (continued)

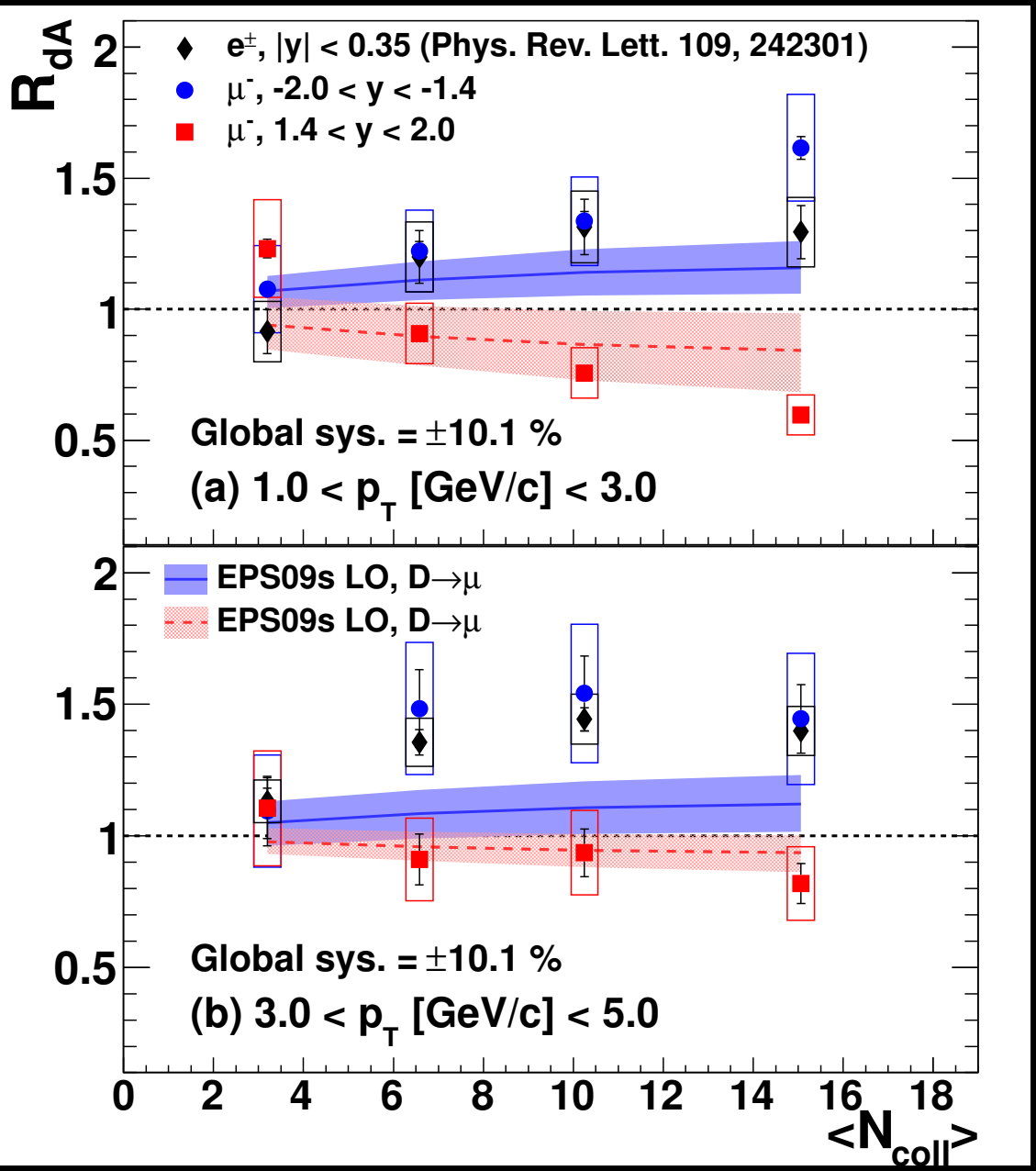
Breaking into most peripheral and most central bins…

Consistent with no CNM modification in peripheral collisions.

Significant enhancement at backward rapidity and suppression at forward rapidity in most central bin.



N_{coll} dependence of R_{dA}



Both rapidities show increasing CNM effects with increasing centrality.

y<0 enhancement similar to that seen in HF single electrons at mid-rapidity.

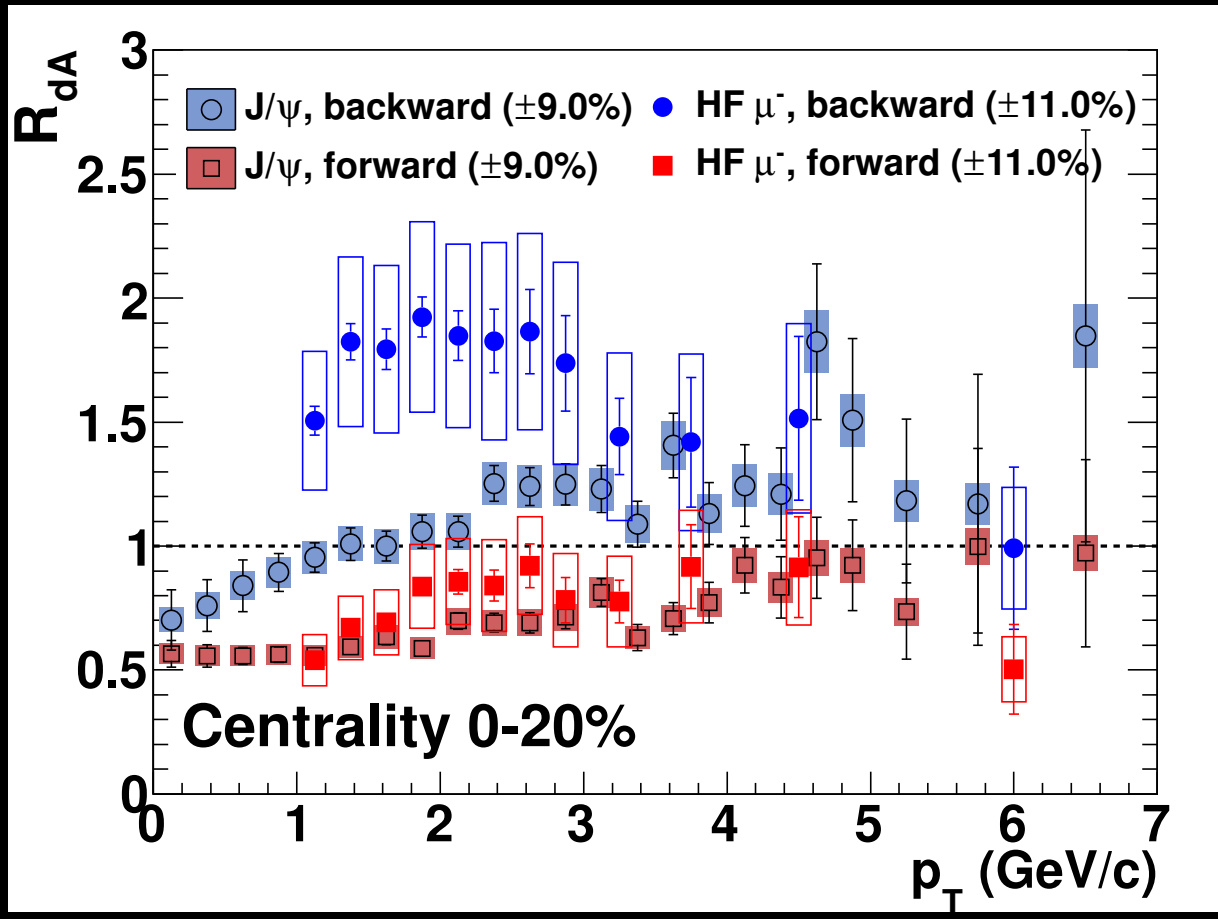
Trend of increasing CNM consistent with EPS09, but stronger at y<0.

Comparison to J/ψ case

Suppression similar at y>0, but enhancement much stronger at y<0.

What does this say about nuclear breakup of the J/ψ vs. CNM effects common to both?

Caveat: p_T bins are probably not comparable between the two.



Summary and Outlook

Significant modification of single muons from heavy flavor decays has been observed in d+Au collisions.

- Enhancement at backward rapidity
- Suppression at forward rapidity
- Effects increase with centrality

The Forward Vertex Detector was installed in 2012 and will allow the separation of *c*- and *b*-quark decays via precise vertex measurement.

Additional steel absorber was also installed in 2012, which will reduce the hadronic backgrounds and increase HF muon S/B.

Cu+Au collisions were recorded for the first time at RHIC with these upgrades, and are being studied now.